Forecasting and Risk (BANA 4090)

Additional Topics

Zhaohu(Jonathan) Fan
07/22/2021

- Main topics:

    - HW # 4
    - Exponential smoothing

HW # 4

Forecast errors

- Forecast "error": the difference between an observed value and its forecast:

    - $e_{T+h} = y_{T+h} - \hat{y}_{T+h|T}$,where the training data is given by $\{y_1, \ldots, y_T\}$.

- R Lab Notes (**selecting values from a matrix in R**).

Exponential smoothing

Exponential smoothing

- **Exponential smoothing methods are**...

  - weighted averages of past observations, with the weights decaying exponentially as the observations get older.

Types of exponential smoothing

- What are the 3 main types of exponential smoothing?

    - Simple exponential smoothing: for series with no trend or seasonality.

    - Holt's method: with trend, no seasonality.

    - Holt-Winter's method: with trend & seasonality.

Exponential smoothing

Big picture

- Forecast future values using a **weighted average** of all previous values in the series.

- Advantages:

    - flexible,
    - computationally efficient,
    - good performance, ease of automation,
    - ease of automation.

A specifical case: Moving average

- **The idea**: Compute value based on average of several observed values.

- **Uses**: Visualization, Forecasting, Computing seasonal indices.

- **Advantages**: Simple, intuitive, popular, data-driven.

- **Key concept**: Width of window.

- **Trailing moving average(trailing MA)**: based on a window from time t and backwards. In R, `ma()` function.

  - To forecast a series at time t+k, use a trailing MA that ends at time t.
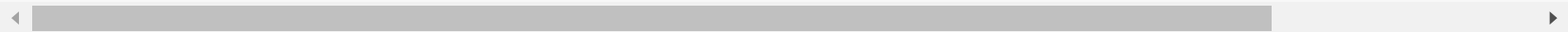
Data Example

- Using the `Natural Gas Sales.xls` data:

    - Identify the preferred window length for moving average

    - Compute and plot a centered moving average

    - Remove the last observation (Fall - 2004) and use a trailing MA to predict for Fall - 2004

    - How does this prediction compare to a seasonal naive estimate?

Data Example (cont'd)

- Import data:

```
setwd("C:/Users/fanzh/OneDrive - University of Cincinnati/UC_couse/000_Teaching_4090_S
gas ← read_excel("Natural Gas Sales.xls",
                col_types = c("text", "numeric", "skip", "skip"))
head(gas,8)
```

```
## # A tibble: 8 x 2
##   Quarter      `Gas Sales`
##   <chr>            <dbl>
## 1 Winter-2001        170
## 2 Spring-2001        148
## 3 Summer-2001        141
## 4 Fall-2001          150
## 5 Winter-2002        161
## 6 Spring-2002        137
## 7 Summer-2002        132
## 8 Fall-2002          158
```
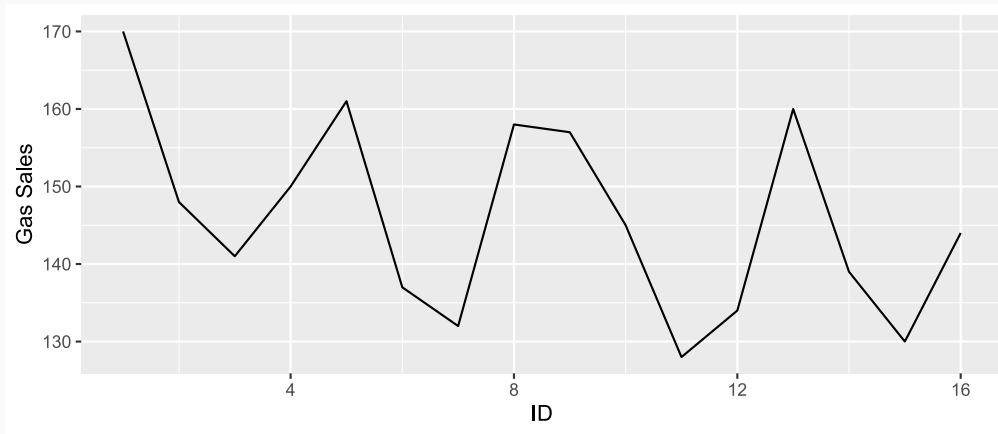
Data Example (cont'd)

- Plot so that we can identify preferred window length.
- Seasonality appears to follow the quarters so an appropriate window length would be 4.

```
gas %>%
  mutate(ID = 1:nrow(gas)) %>%
  ggplot(aes(ID, `Gas Sales`, group = 1)) +
  geom_line()
```

Data Example (cont'd)

- Convert to a time series object:

```
gas.ts ← ts(gas[2], start = c(2001, 1), frequency = 4)
gas.ts
```

```
##      Qtr1 Qtr2 Qtr3 Qtr4
## 2001  170  148  141  150
## 2002  161  137  132  158
## 2003  157  145  128  134
## 2004  160  139  130  144
```
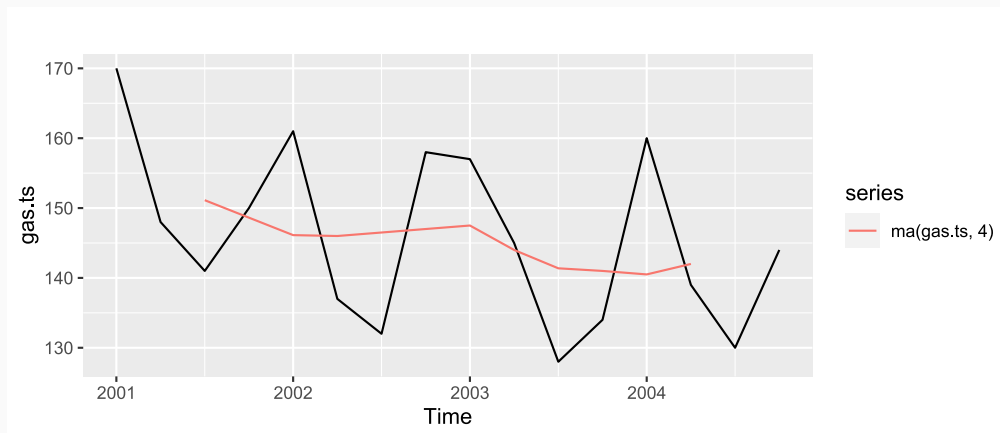
Data Example (cont'd)

- Compute and plot a moving average:

```
ma(gas.ts, 4)
```

```
##            Qtr1     Qtr2     Qtr3     Qtr4
## 2001        NA       NA 151.125 148.625
## 2002 146.125 146.000 146.500 147.000
## 2003 147.500 144.000 141.375 141.000
## 2004 140.500 142.000      NA      NA
```

```
autoplot(gas.ts) +
  autolayer(ma(gas.ts, 4))
```

- Partition data to remove the last observation as test data:

```
train ← window(gas.ts, start = c(2001, 1), end = c(2004, 3))
train
```

```
##       Qtr1 Qtr2 Qtr3 Qtr4
## 2001  170  148  141  150
## 2002  161  137  132  158
## 2003  157  145  128  134
## 2004  160  139  130
```

```
test ← window(gas.ts, start = c(2004, 4), end = c(2004, 4))
test
```

```
##       Qtr4
## 2004  144
```

Data Example (cont'd)

- Use trailing MA to predict Fall 2004:

```
ma ← forecast(rollmean(train, 4, align = "right"), h = 1)
ma
```

```
##          Point Forecast    Lo 80    Hi 80   Lo 95    Hi 95
## 2004 Q4        140.7499 137.5859 143.9139 135.911 145.5889
```

Data Example (cont'd)

- Use seasonal naive model to predict Fall 2004:

```
sn ← snaive(train, 1)
sn
```

```
##              Point Forecast     Lo 80     Hi 80     Lo 95     Hi 95
## 2004 Q4                 134  121.3723  146.6277  114.6875  153.3125
```

Data Example (cont'd)

- Compare the accuracy of the two methods:

```
accuracy(ma, test)
```

```
##                        ME      RMSE      MAE        MPE     MAPE      MASE
## Training set -0.9554378 2.358523 1.836250 -0.6658609 1.269043 0.4052414
## Test set      3.2500524 3.250052 3.250052  2.2569808 2.256981 0.7172529
##                      ACF1
## Training set -0.1962972
## Test set             NA
```

```
accuracy(sn, test)
```

```
##                     ME      RMSE MAE       MPE     MAPE MASE       ACF1
## Training set -4.181818  9.853472   8 -3.122110 5.666473 1.00 -0.1788168
## Test set     10.000000 10.000000  10  6.944444 6.944444 1.25         NA
```